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THE STATE OF WYOMING

GEOLOGIST'S OFFICE

Bulletin Number 11

PART I.

The Little Buffalo Basin Oil and Gas Field

and

PART II.

The Grass Creek Oil and Gas Field

By F. F. HINTZE, Jr.

L. W. TRUMBULL, STATE GEOLOGIST

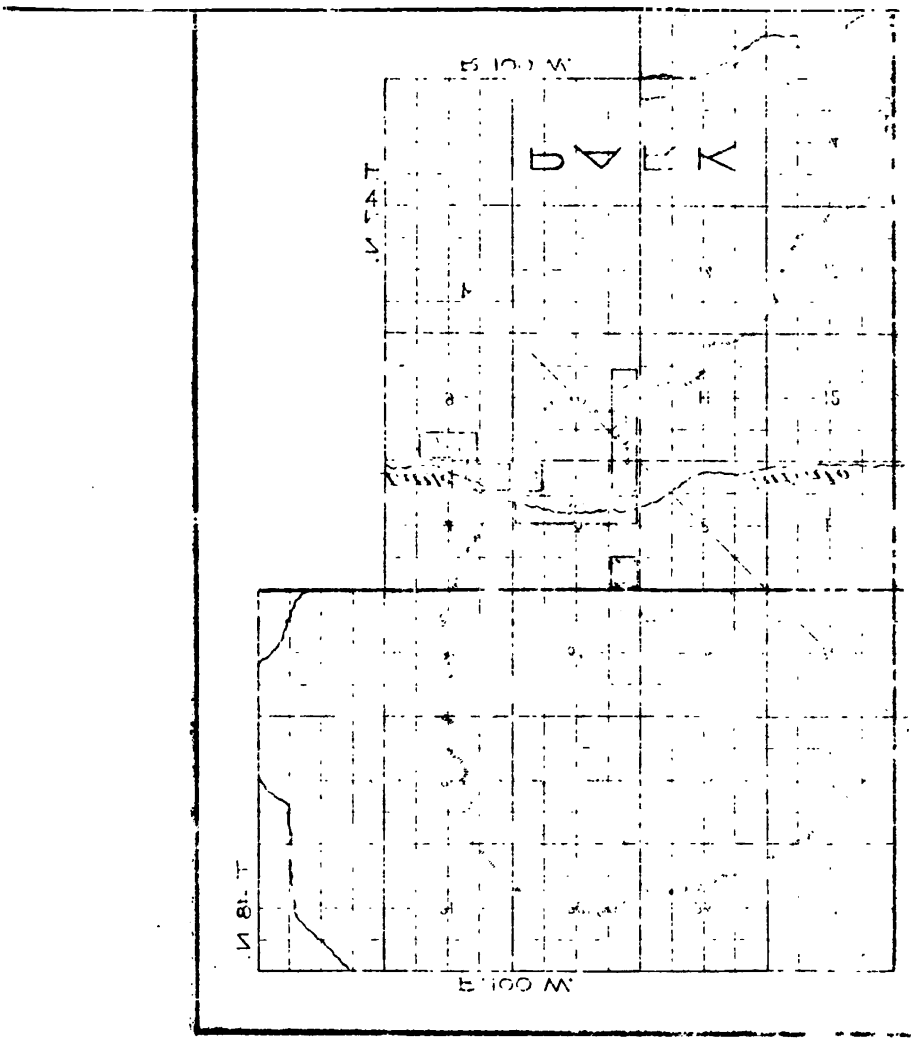
1915
THE S. A. BRISTOL COMPANY,
CHEYENNE, WYO.

557.4
W71

TABLE OF CONTENTS

PAGE

Introduction 67
Acknowledgments 68
Location of Field 68
Geology 69
  Topography 69
  Physiography and Drainage 70
  Stratigraphy 72
    Introduction 72
    Table of Formations 73
    Description of Formations 74
    Lower Cretaceous System 74
      Cloverly Formation 74
    Upper Cretaceous System 74
      Colorado Group 74
        Benton Formation 74
        Wood River Section of Upper Benton 75
        Basin Shale 76
      Montana Group 77
        Pierre Shale 77
        Eagle Sandstone 79
        Meeteetse Formation 80
        Ilo Formation 80
Structure 81
  General Statement 81
  Big Dome 82
  Little Dome 82
  Faulting 83
Gas Occurrence 83
Oil and Gas Sands 84
  Benton Sandstones 84
  Mowry Beds 85
  Cloverly Formation 85
The Wells 85
  Log of Midwest Well No. 1 86
  Log of Ohio Oil Company's Well 87
Production 88
Possibilities of Development 90
Explanation of Structure Contours 90



especially on the margins where the outcrops are good.

*Jamison, C. E., Mineral Resources of Wyoming. Bull. No. 1, Series B., p. 21, 1911.

557.4
W71

TABLE OF CONTENTS

PAGE
Introduction 67
Acknowledgments 68
Location of Field 68
Geology 69

AGE
.67
.68
.68
69

The Little Buffalo Basin Oil and Gas Field

Park and Hot Springs Counties, Wyoming

INTRODUCTION

Prospecting for oil and natural gas at various places within the Bighorn Basin has been going on during the last few years, and interest has risen steadily, until at present more than a dozen favorable structures have been tested with bore holes. Indications of the existence of oil and natural gas were first reported from the eastern side of the basin, along the foothills of the Bighorn Mountains,* but during the last year several dome structures on the west side of the basin have been prospected with very encouraging results. The newest of these western fields is the Little Buffalo Basin, in which the first wells were drilled last summer, resulting in the discovery of large quantities of natural gas.

During August, 1914, the field data, on which the present report is based, were gathered by the writer and his party associates, Messrs. Herbert L. Kennedy, Warren F. Hadsall, Gerald Coons, and Walter Storrie. A geologic map was made of the formations exposed within the basin, and sections were carefully measured in the basin, and on Wood River, about a mile below Sunshine. Dips and strikes were determined for many points within the basin, especially on the margins where the outcrops are good.

*Jamison, C. E., Mineral Resources of Wyoming. Bull. No. 1, Series B., p. 21, 1911.

The topographic map of the Meeteetse quadrangle, issued by the U. S. Geological Survey, was used as a guide in the determination of elevations at various starting points. Formation boundaries were traversed with plane-table and telescopic alidade. Distances were measured by stadia, and profile lines were run with transit and stadia measurements. From the data thus gathered, calculations were made and structure contours were drawn, showing the surface character of the top sandstone of the Benton, as represented on the structure map following Page 80 of this report.

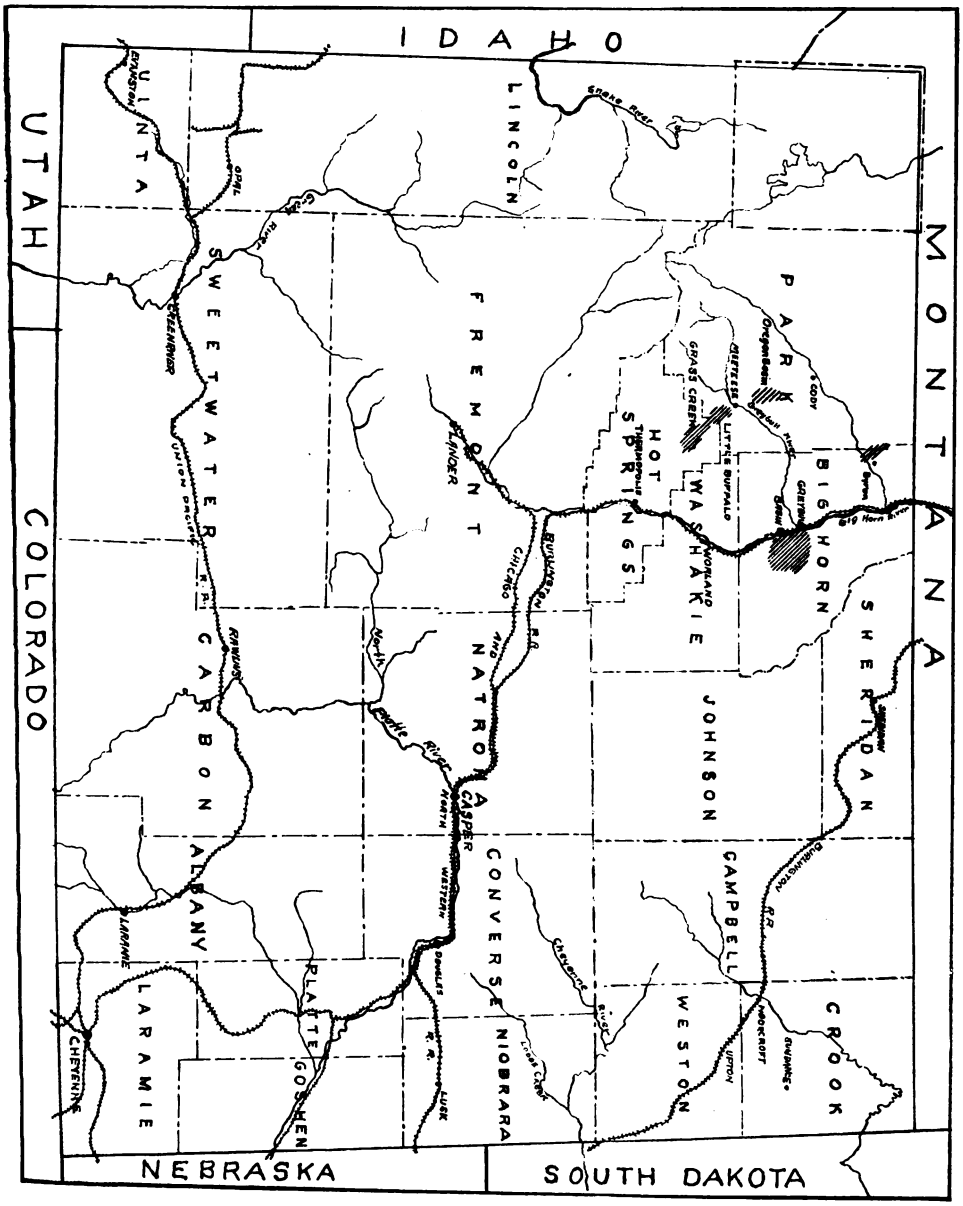
ACKNOWLEDGMENTS

Thanks are due to the companies operating in the Little Buffalo Basin for their hospitality, and for their willingness to furnish information regarding the results of drilling. Special thanks are due to Mr. T. S. Harrison, of Wiley, Wyo., Mr. W. J. Walker, Geologist, Basin, Wyoming, Expert for the Fullerton Oil Co., and Mr. John McFadyen, Thermopolis, Wyo., Manager of the Ohio Oil Co., for logs of all wells of their respective companies. To Mr. M. D. Woolery, Civil Engineer, Thermopolis, Wyoming, thanks are due for pointing out the newly established land corners, and for the use of his preliminary map of the basin.

LOCATION OF FIELD

The Little Buffalo Basin oil and gas field is located in Park and Hot Springs Counties, Wyoming, on the west side of the Bighorn Basin. It can be reached from points on the Bighorn branch of the Burlington Railroad, by automobile, or livery, from Worland, Basin, or Greybull; or by stage from Greybull, or Cody, to Meeteetse, and thence by special conveyance. Meeteetse, on the Greybull River, is the largest business center close to the basin, the distance by way of the road being about 10 miles, via Iron Creek and the west entrance, and 12 miles by the eastern route.

PLATE I.


IDAHO
MONTANA
UTAH
COLORADO
NEBRASKA
SOUTH DAKOTA
UINTA
LINCOLN
SWEETWATER
FREMONT
PARK
HOT SPRINGS
WASHAKIE
BIG HORN
SHERIDAN
CARBON
NATRONA
JOHNSON
ALBANY
CONVERSE
CAMPBELL
LARAMIE
PLATTE
GOSHEN
NIOBRARA
WESTON
CROOK
CASPER
CHEYENNE
LANDER
CODY
GRASS CREEK
LITTLE BUFFALO
WORLAND
RAWLINS
LARAMIE
DOUGLAS
LUSK
UPTON
HOOKCROFT
GREENRIVER
OPAL
Snake River
Big Horn River
North Platte River
Cheyenne River
Lost Creek
Burlington R.R.
Union Pacific R.R.
Chicago and North Western R.R.

the dip of the rocks is least the cliffs are almost perpendicular. Along the eastern rim, the ridge is practically straight, with a series of peaks and intermediate shallow saddles. At the north end the ridge is less simple, and long rugged spurs lead down into the basin. On the west, the northern half of the rim is rather simple and straight, but south of the water-gap there is a pronounced curve to the east for nearly two miles before the southern continuation is reached. This curve has its explanation in the structure and will be referred to again under that heading.

Physiography and Drainage

Little Buffalo Basin is located in a region that was strongly folded in early Tertiary time, and was subsequently eroded on a large scale, resulting in the cutting away of the tops of the more prominent folds. These events were followed by several uplifts, that occurred periodically, but sufficiently separated in time to allow the principal streams to cut broad valleys, or meander plains, by lateral planation. The lowering of the valley level by uplift of the region, or by the removal of barriers which may have held the outlet of the waters at stationary levels long enough to permit extensive planation, caused the formation of a series of partial peneplains, each one lower than the preceding ones, which are then only represented by terrace-like remnants. It is possible to identify at least three of these well-marked peneplain levels near the head of the Greybull River, and on Wood River. This region is, therefore, in the *nth* cycle of erosion, if we consider each uplift following a period of erosion, as initiating a new cycle.

A good example of the highest one of these terrace levels may be seen on the topographic map, (U.S.G.S.) in Sections 9 and 16, T. 47 N., R. 101 W., about a mile north of Sunshine, on Wood River. The hill is not more than one-quarter mile wide, and about a mile long, but has a nearly flat top which slopes gently northward. East of Wood River, in the northeast quarter of Section 22, is a

small flat-topped hill of irregular outline which rises to this same level. Still farther east, in Sections 13, 24, and 25, and in Sections 18 and 19 of the next township, is an upland which is being dissected but which rises to about the same elevation as the terraces on Wood River. The elevation of the tops of the hills farther north, between Iron Creek and Wood River, is only slightly less, and shows that the slope of the peneplain was toward the north. This is further shown in the region beyond the Greybull River, directly north of the area under discussion, where the flat-topped hills rise to a level still lower, indicating the continuation of the slope toward the north. When a still larger area is considered, the slope for the region as a whole is to the northeast. The course of the Greybull River was determined largely by this slope.

The present drainage of the Little Buffalo Basin is to the east, into Gooseberry Creek, and thence to the Bighorn River. This is not what should be expected from the northeast slope of the region. It is furthermore difficult to understand how a small intermittent stream, like Little Buffalo Creek, could cut the two deep water-gaps seen in the east and west rims of the basin. The water which enters the basin through the west gap at present comes from a very small drainage area near the head of Iron Creek. The divide between these two streams is more than 300 feet lower than the top of the ridge through which Little Buffalo Creek has cut its gap. It seems clear that capture must have taken place here, and that either Iron Creek has robbed Little Buffalo Creek of its head waters, or Little Buffalo Creek has been reversed in its direction of flow due to a capture east of the basin. The latter view is preferable because, in that case, a larger drainage area east of the basin is provided, from which Little Buffalo Creek could gather considerable water with which to cut the gaps. The stream which performed the capture was a tributary to Gooseberry Creek. This small subsequent stream developed its valley by headward erosion on soft shales that overlie the resistant sandstone forming the rim of the basin.

The floor of the Little Buffalo Basin consists of soft

shales which have been rapidly eroded, while the resistant sandstones surrounding the basin have been left standing. These shales were exposed when the region was peneplained, and during the early stages of dissection, when Little Buffalo Creek flowed westward into the Greybull River, sediments were carried out that way. Since the reversal of the flow of Little Buffalo Creek the floor of the basin has been carried down to its present level in, at least, two cycles. There are flat-topped ridges and small outlying hills in the basin that rise to such a level that, if the intermediate depressions were filled in, the basin floor would be even and gently inclined from the sides toward the center.

STRATIGRAPHY

Introduction

The rocks exposed in the Little Buffalo Basin oil and gas field are all of Cretaceous age, and belong chiefly to the Montana group. The top of the Colorado shale is exposed in a small area in the south-central part of the basin. This is surrounded by the later Pierre shale which occupies most of the basin floor. Overlying this formation is the Eagle sandstone which forms the walls and rim of the basin. Outside the rim of the basin are the later Montana sediments, known as the Meeteetse formation.

The succession of formations together with their thickness and chief characteristics are shown in the following table:

PLATE II-A.

View of Cretaceous section on Wood River, one mile below Sunshine, looking east. Top sandstone of Benton seen on the river escarpment to the right of the center. Eagle sandstone ridge in background, Basin and Pierre shales between. Shows river "terrace of planation", the former level of the stream seen in the foreground.

PLATE II-B.

Hogback ridges of Upper Benton Sandstones as seen in an outcrop on Wood River, one mile below Sunshine. Showing the characteristic growth of trees along the sandstone outcrops, with barren shales between.

TABLE OF FORMATIONS

SYSTEM	GROUP	FORMATION	THICKNESS IN FEET	CHARACTERISTICS
EOCENE		Fort Union	3000	Gray and drab sandy shales, and light brown massive sandstones. Conglomeratic in the lower part.
		UNCONFORMITY		
UPPER CRETACEOUS		Ilo	900 to 850	Buff and yellow sandstones, with minor sandy shale and clay. No coal beds; saurian bones and fresh-water invertebrate fossils.
	Montana	Meeteetse	1000 to 1100	Dark and light gray alternating shales and shaly sandstone, and numerous beds of lignitic coal.
		Eagle	500 to 600	Hard gray and light brown massive sandstones alternating with more thinly bedded shaly sandstone, locally coal-bearing in the lower part. Forms high ridges, due to superior hardness.
		Pierre	1300 to 1400	Light gray and light brown sandy shales and massive layers of sandstone near the top. Softer and darker shales in the lower part, with zones of brown sandy shales. Fossiliferous in upper third. *Scaphites hippocrepis* DeKay, *Baculites ovatus*, etc.
	Colorado	Basin (Niobrara)	1200 to 1250	Soft, black, adobe shale with limestone concretions often highly fossiliferous. Streaks of hard, red, calcareous shale near the top, often very fossiliferous. *Baculites anceps*, *Scaphites ventricosus*, *Inoceramus*, etc., common near the top.
		Benton	1300 to 1400	Heavy buff and brown sandstones at top, separated by sandy shales making up 585 feet; followed below by hard, gray, sandy shales with numerous fish-scales—the Mowry beds. Below the Mowry are black adobe shales and gray sandstones. Black and dark gray shale, with rusty sandstone at the base.*
LOWER CRETACEOUS		Cloverly	100 to 300	Gray, green and maroon shales, and massive gray sandstone.

*The description of the lower part of the Benton here given is taken from the section given by Mr. E. G. Woodruff in his report on the coal fields of the southwest side of the Bighorn Basin, U. S. Geol. Survey Bull. 341, p. 202, 1909.

Description of Formations

LOWER CRETACEOUS SYSTEM

Cloverly Formation. The Cloverly formation does not outcrop in the Little Buffalo basin, the nearest exposure being 15 miles distant, on Gooseberry Creek, southeast of Sunshine. At this outcrop it shows the same general characters exhibited elsewhere in the Bighorn Basin.

No bore holes have been put down in Little Buffalo Basin deep enough to reach the Cloverly, so that the exact thickness and characters for that place cannot be given. It is quite surely present, however, as it is known to be of widespread occurrence. The Cloverly usually consists of alternating sandstone and arenaceous shale, or clay. The clays are usually bright-colored, green, buff, maroon, and red, and the sandstones are light greenish gray in color. Typical exposures show a basal sandstone that is often conglomeratic, varying from 10 to 50 feet in thickness, followed by the highly colored clays, and a massive or cross-bedded sandstone at the top. Locally, one, or even both, of the sandstones may be absent or replaced by softer materials so as to render the outcrop inconspicuous, but usually the Cloverly forms ridges, and the sandstone outcrops support pine tree growth and can be recognized in that way.

UPPER CRETACEOUS SYSTEM

COLORADO GROUP

Benton Formation. The Benton formation does not outcrop in the basin, or its immediate vicinity. On Wood River, seven miles to the west, the upper part is exposed and on Gooseberry Creek, southeast of Sunshine, the entire formation outcrops.

The estimated thickness of the Benton is 1400 to 1600 feet as shown on the columnar section. (See plate preceding Page 81.) A deep boring in the Grass Creek field shows the thickness of the Benton there to be between 1300 and

1400 feet, and it may be that 1400 feet is the closest approximation possible for Little Buffalo Basin, until a test hole is drilled.

The base of the Benton usually begins with the so-called Rusty Beds, which are sandy shales that weather to a rusty-brown color. These range in thickness from 100 to 150 feet, and are succeeded by dark-gray and black adobe shale. Occasional layers of gray sandstone occur at intervals in the black shales. A little above the central part, the hard, gray sandy shale, bearing numerous fish scales, and commonly known as the Mowry shale, occurs. This member is well shown on Wood River, lying a short distance below the massive sandstones and sandy shales of the upper part of the Benton.

The top of the highest massive sandstone is, on lithologic grounds, taken to be the top of the Benton. The overlying dark shales carry upper Colorado, or Niobrara fossils at a horizon about 600 feet above the upper massive sandstone, but as these shales are elsewhere fossiliferous immediately above the sandstone, as at Basin, Wyoming, the dividing line is placed at the top of the sandstone instead of higher up.

On Wood River, about a mile below Sunshine, the following section of the upper part of the Benton was measured:

SECTION OF UPPER PART OF BENTON FORMATION, ON WOOD RIVER

		FEET
	Superformation, Niobrara black shale	
8.	Light brown sandstone, upper layers conglomeratic	62
7.	Sandy shale and dark adobe shale	167
6.	Light gray massive sandstone	64
5.	Light brown and gray, thick-bedded sandstone	108
4.	Hard, white, massive sandstone	54
3.	Light brown, sandy shale, thin-bedded	83
2.	Massive hard, gray sandstone	45
1.	Hard, bluish-gray, fish-scale, sandy shales (Mowry)	150
	Base not exposed.	
	Total	733

The massive sandstones Nos. 2, 4, 6 and 8, are shown on the plate II-B. The highest one, No. 8, is shown at the extreme left. The softer shales of bed No. 7 form the deep depression between beds Nos. 8 and 6. The shales

separating the other sandstone layers are more resistant, but can be recognized by the absence of trees along the outcrop. This group of sandstones is of great practical importance, as they constitute the gas sands of Little Buffalo Basin, and the gas and oil sands of the Grass Creek field. The whole group including the Mowry shales, composes the upper half of the Benton formation. Below the Mowry the Benton is largely soft black shale, until the Rusty Beds, which are sandy, are reached near the base.

Basin Shale. Overlying the highest massive sandstone layer of the Benton is a black shale series 1200 to 1250 feet thick, carrying numerous fossils in the upper half, and especially near the top. The best exposures of this formation are in the bad-lands, two miles east of the town of Basin, Wyoming, from which locality the name Basin shale is derived. The uppermost layers of this shale are exposed in the south-central part of Little Buffalo Basin, in a small area of about a square mile, located in Sections 1 and 12, T. 47 N., R. 100 W. The entire formation is exposed on Wood River where a thickness of 1215 feet was observed between the top of the Benton and the base of the Pierre shale. The upper limit is not as well defined, lithologically, as might be desired, but an easily recognized series of black shales which carries thin layers of hard, red, calcareous shale is taken to be the top. Above these black and red shales, light brown sandy zones begin to appear and these become more numerous toward the top of the Pierre. Moreover, the fossils of the Basin shale do not appear above the red shale streaks. There seems to be a continuous depositional series from the upper Colorado into the Montana, and the lack of closely placed fossil beds defining the exact dividing line makes the separation more or less arbitrary. As here divided, the Colorado includes only known Colorado strata, whereas the lower limit of the Pierre may be a trifle too low.

The lower 800 feet of the Basin shale is soft, black, adobe shale, weathering to a blue-black mud. Between 800 and 900 feet above the base, glauconitic green sand is abundant in layers as much as three feet thick. Above

the green sand the shale is black and contains many calcareous concretions, until the upper 100 feet is reached, where the thin red shales appear intercalated with the black shale.

The following is a list of the fossils found on Wood River, in the upper half of the formation:

Scaphites ventricosus
Placenticeras sp. (smaller than placenta)
Inoceramus cf. deformis
Inoceramus acute plicatus
Inoceramus exogyroides
Baculites anceps
Baculites asper
Ostrea congesta (on *Inoceramus*)

Scaphites ventricosus and *Baculites anceps* were also found in the Little Buffalo Basin exposure, in Sections 1 and 12, T. 47 N., R. 100 W.

MONTANA GROUP

Pierre shale. Surrounding the Basin shale and occupying the rest of the floor of the basin is a sandy shale series of lower Montana age to which the name Pierre shale is given. At Basin, Wyoming, a similar series is found in a corresponding stratigraphic position and the formation is believed to be present throughout the Bighorn Basin. The following fossil forms were collected by the writer in the southern part of the Basin field, just south of the Hyattville road, in T. 51 N., R. 93 W.:

Placenticeras whitfieldi
Baculites compressus
B. ovatus
Scaphites hippocrepis var.
Scaphites sp. (new)
Ammonites sp.
Nautilus dekayi
Pholadomya sp. (new)

A collection of fossils was also made from the Pierre shale in the northeast quarter of Section 10, T. 47 N., R. 100 W., in Little Buffalo Basin, from which the following forms were identified:

Baculites compressus
Scaphites hippocrepis var.
Inoceramus sp.

Besides these, numerous small bivalves, similar to *Nucula cancellata* M. & H., and *Cardium speciosum* M. & H., were found at the same horizon.

The Pierre shale as here defined has usually been included in the Colorado group, as was done by Hewett in his paper on the Shoshone River section* and by Woodruff in his coal report†. The discovery of the Pierre fauna about 1000 feet below the base of the Eagle sandstone at Basin, and between 400 and 500 feet below the Eagle in Little Buffalo Basin, has led the writer to place these shales in the Montana. A local name would be more appropriate, as these shales probably do not represent the whole of the Pierre. but as a suitable locality name has not been found, the old term has been used.

The thickness of these sandy shales as measured on the east side of Little Buffalo Basin, between the lowest massive layer of the Eagle sandstone and the top of the Basin shale, is 1315 feet. This is somewhat less than was found on the east side of the Bighorn Basin, where the Pierre is more than 1600 feet thick. At Grass Creek the thickness of the Pierre is 1575. The fossil horizon in Little Buffalo Basin is nearer the top than it is at Basin, and it is believed that the somewhat less thickness of shale is due to the greater thickness of the overlying sandstones which come in and replace the shale. This is shown by tracing the lower massive sandstone along its outcrop, when it is seen to pass into shale. No single massive sandstone at the base of the Eagle was found to be continuous around the entire basin, which shows that the shales and sandstones at this horizon replace one another, at least to some extent. The lithologic character of the shales of the lower part of the Pierre seem to be more constant over wide areas, which is probably due to their truly marine character. The lack of marine fossils and the presence of coal beds in the Eagle indicate a non-marine origin for that formation, and fresh water deposition may have begun

*U. S. Geol. Survey Bull. 541-C, p. 45, 1914.

†U. S. Geol. Survey Bull. 341, p. 203, 1909.

earlier in some regions than in others, causing the thickness of the marine beds to be less in such places.

At a short distance below the top of the Pierre the sandy layers become greatly thickened locally, insomuch that they form a low escarpment roughly parallel to the main escarpment of Eagle sandstone. These layers are generally continuous for short distances only, and often disappear altogether, being replaced by softer shales. In a few places, as in the southeast part of Little Buffalo Basin, these beds become so massive, and the shale which separates them from the Eagle becomes so sandy that it is difficult to follow a definite horizon at the base of the Eagle, such as is necessary in mapping the boundary line between the Eagle and Pierre.

Eagle Sandstone. The name Eagle has been applied to the sandstone formation which overlies the Pierre shale. This is a continuation of the practice of Fisher, Washburne, and Woodruff, who have used this name for these same sandstones, but in a different sense. According to its original definition it applies to a sandstone at the base of the Montana, and in that sense it was used in the coal reports. The discovery by the writer of a Pierre fauna considerably below this horizon makes the continuation of the name Eagle for this sandstone technically inadvisable, but it has become known and is in common usage among drillers and local mining men, which gives it a practical value that cannot be totally disregarded. For this reason it has been adopted for use in this report.

The Eagle sandstone consists of a mass of light-yellow to light-brown sandstones in beds varying from a few feet to 60 feet in thickness. Thick massive sandstones are particularly conspicuous in the lower part. Locally, workable beds of coal also occur near the base of the formation.

The thickness assigned to the Eagle sandstone in this report is merely a rough estimate and does not represent exact measurements. No special study was made of the upper limits of the formation, nor of the details connected with the overlying Meeteetse and Ilo formations, as these

are of minor importance in connection with the occurrence of oil and gas in Little Buffalo Basin.

Meeteetse Formation. The name Meeteetse formation has been applied by Hewett to a group of beds overlying the Gebo formation, which represents the Eagle sandstone and the Claggett formation of the Montana sections. The following is a statement of the main characters of the formation.*

> "The conspicuous features of the formation are the presence of a number of beds of carbonaceous shale and coal and the general absence of induration of the beds. Along Shoshone River and also throughout the greater portion of the region south from the river to Owl Creek, carbonaceous shale and coal beds are largely confined to the upper half of the formation, and though on the river there is but one bed of coal more than 14 inches thick—that which has been mined by the Cody Coal Co.—in the neighborhood of Meeteetse some sections contain as many as five beds. The beds are, however, highly lenticular and the coal is poor in quality compared to the coals in the underlying Gebo formation and the higher Fort Union formation. Somber colors prevail throughout the formation, the greater portion of the beds being gray to olive colored."

Ilo Formation. The Ilo formation consists of massive yellow sandstone beds ranging from 20 to 60 feet in thickness. Indurated clay and argillaceous sand alternate with the sandstone. Vertebrate and invertebrate fossils, found in zones near the central part of the formation, indicate the age to be the same as the "Ceratops beds". The thickness of the formation according to Hewett is 850 feet, two miles west of Meeteetse, and 810 feet in the type locality, near Ilo, Wyoming.

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*Hewett, D. F., The Shoshone River Section, Wyoming, U. S. Geol. Survey Bull. 541-C., p. 56, 1914.

HT

STRUCTURE

General Statement

Little Buffalo Basin consists of two unequal domes whose long axes are approximately parallel to each other and run about N. 35°-40° W. A shallow syncline separates the two domes along a line which makes an angle of about 45 degrees with the axial direction. The outer margins of the domes are defined by the steep escarpment, due to the resistant Eagle sandstone member, which forms the rim-rock of the basin. The line of contact of the two domes is not expressed in the topography, since the softer shales of the central part of the basin are here involved. The two-fold dome structure of Little Buffalo Basin may be inferred from the form assumed by the rim-rock, especially on the west side of the basin, where the southern end of the most northern one of the two domes is marked by a pronounced curve in the sandstone escarpment. Further proof is found in the directions of dip and strike of the beds within the basin. Unfortunately, outcrops on the floor of the basin are not as good as might be desired, but in some of the deeper washes the bed-rock was found to be exposed, and here the final proof of the double-dome structure was obtained.

The condition thus briefly stated is almost exactly duplicated in the Grass Creek oil and gas field where two domes of unequal size are similarly placed with respect to each other. The form of these domes is not so nearly like those of Little Buffalo basin, but in their essential character (asymmetrical and steepest to the west and southwest) they correspond perfectly. In the Grass Creek field erosion has not removed all of the hard sandstone from the syncline between the domes, making their relation to one another more evident than is the case at Little Buffalo Basin.

For the purposes of description the two domes may be referred to as the big dome and the little dome.

The Big Dome

The larger of the two domes is the one occupying the southeastern and central portions of the basin. The center of the big dome lies in Sections 1 and 12, T. 47 N., R. 100 W. This is nearer the west side of the basin, which is to be expected since the dip on this side is steeper than it is to the east. The structure across the big dome from N. E. to S. W. is shown by section C-C′ (on plate following Page 80) and the form of the dome is clearly indicated on the structure map, immediately following.

The elevation of the upper surface of the highest massive sandstone of the Benton (see columnar section, second plate) at the center of the dome is a little over 4700 ft. above sea level. On the east side, along section C-C′, the surface of this sandstone member turns gradually down and descends to an elevation of about 3200 feet above sea level along the line vertically below the lowest outcrop of the Eagle sandstone. On the west side the descent is more rapid, but the horizontal distance to the outcrop of the Eagle is less, so that vertically below the lowest outcrop of the Eagle sandstone on this side, the contoured member has an elevation of 3400 feet above sea level.

At the southern end, the dip is more gentle and the Eagle sandstone laps up higher on the dome, the innermost outcrop, near the end of section A-A′ coming vertically over structure contour 3800. At the north end the big dome descends very gently, spreading out both to the east and the north. The syncline, or sag, between the two domes asserts itself most at the point of contact, and gradually disappears to the northward so that along the outcrop of the Eagle sandstone at the north end of the basin, there is no evidence of two domes, but of one only.

The Little Dome

The northwestern part of the basin is occupied by the little dome, the top, or center, of which lies in Section 3, T. 47 N., R. 100 W., and Section 34, T. 48 N., R. 100 W.

The little dome is 200 ft. higher in the center than the big dome, and is steeper on both sides, but especially toward the west where the dip is 46° at the west end of section B-B′. The structure across the dome in a NE-SW direction is shown in section B-B′ of the section sheet, and the general form of the dome is shown on the structure map. (See two preceding plates).

The contoured surface of the Benton rises to an elevation of a little more than 4900 feet above sea level at the center of the little dome. The top of the dome is narrow and elongated as compared with that of the big dome, which is more broadly ellipsoidal.

Through an oversight in drafting two important dip and strike signs were not copied on the map. One of these belongs about one-quarter mile northwest of well No. M-1, which is located in Section 25, T. 48 N., R. 100 W., where the dip was found to be 10 degrees to the northeast. A half mile southeast of this place the dip flattens to 4 degrees. The other important observation was made in the wash of Little Buffalo Creek, one-half mile west of well No. O-1, of the Ohio Oil Company. At this point the strike is north and south, and the dip is 7 degrees to the east.

Faulting

Evidence of faulting was not observed within the basin. The rim-rock was followed completely around the basin but no dislocations were noted anywhere.

GAS OCCURRENCE

Gas has been found in the upper half of the sandstone member near the top of the Benton formation, where these beds have been arched up in the form of a dome. The gas exists in the pore space of the more open sandstone layers, and is kept from escaping by the covering of tight shales which form a thick capping over the center of the domes and down the side and end slopes. The gas in its effort to rise to the surface has been trapped, wherever the containing sandstone layers have been bowed upward.

The center of the dome has not been eroded away so that the gas could escape. The upper limit of any water that may be forced up the sides of the dome, by hydrostatic pressure, would sink, as the gas collects. Slow accumulation of gas for long periods of time often results in the expulsion of the water from the upper part of the dome structure and its migration to a position far down on the sides of the dome. In a series of sandstones and shales, this action may be confined to certain layers only, while others may be dry, or may contain water. This seems to have been the case in the Little Buffalo Basin, where only certain beds of a rather thick series of sandstones, are productive of gas, while others give only water.

The first three wells drilled in the basin were all located at a considerable distance from the crest of the domes, and as gas was obtained in all of them, it is fair to assume that the domes are filled with gas to some level below that at which the wells tapped the sands. To obtain oil, drill holes must be located farther down the sides of the domes. The exact distance can only be determined by trial. The most favorable location for such test holes is near the eastern outlet of the basin, as here the surface is at its lowest elevation inside the basin, and the structure is such as to give the productive sands greater depth.

THE OIL AND GAS SANDS

Benton Sandstones. The highest productive sandstone of the Little Buffalo field is of Benton age, being the upper part of that formation. There are several massive sandstones near the top of the Benton that are separated by sandy shales as seen in the nearest outcrop, on Wood River, and any, or all, of these may locally become productive. (See section under Benton, and view in Plate II-B). In the wells that have thus far been drilled in Little Buffalo Basin, the upper sand usually shows a small amount of water, and is encountered at a depth ranging from 1375 to 1465 feet below the surface. It varies in thickness from

PLATE III-A.

Outcrop of Eagle Sandstone, Little Buffalo Basin. Showing characteristic massive layer, modified by wind erosion.

PLATE III-B.

Standard Drilling Rig of the Ohio Oil Company's Well No. O-1, Little Buffalo Basin. Looking west. Rim-rock of Eagle Sandstone in the background.

62 to 75 feet, in the two wells, O-1 and M-1, and is followed below by a series of dark sandy shales, approximately 155 feet thick, lying between it and the next massive sandstone. Gas and water are found in the upper part of this second sand, and a large flow of gas at a depth of about 50 feet from the top. This is called the "big gas" sand, and its horizon is very close to the middle part of the sandstone series of the upper part of the Benton.

Mowry Beds. Below the Benton sandstones are the fish-scale bearing sandy shales of the Mowry. These are productive at Basin, Wyoming, and in several other fields, and if deeper drilling is done in Little Buffalo Basin, oil or gas may be found in them. This cannot be predicted with any certainty, but there is a fair chance that they will be found productive of oil or gas.

Cloverly Formation. Below the Benton, at a distance of from 1000 to 1100 feet below the "big gas" sand, the top of the Cloverly will be reached. This horizon is productive near Greybull, and it may be found productive in this field. There seems to be no reason to doubt that the formation is present, but until a test hole has been drilled, it is impossible to say whether it is of such a character that it holds oil or gas.

THE WELLS

Four wells have been drilled up to the present time in Little Buffalo Basin, by four development companies. In all of these practically the same conditions have been found, water and gas being encountered at the same horizons with very few exceptions. Unfortunately there is no uniform method of recording log data and some allowance has to be made, therefore, for the apparent differences. On the whole, the logs of these first wells agree very closely, and there is no difficulty in connecting the logs with the succession of beds noted on the surface.

Well No. M-1. Owned by the Midwest Oil Company, Casper, Wyoming. Located in the southwest corner of

the southwest quarter of Section 35, T. 48 N., R. 100 W. Elevation at the top of the casing 5950 feet above sea level. Drilled during August and September, 1914. The following is the log of this well, as furnished by Mr. T. S. Harrison:

LOG OF MIDWEST WELL NO. M-1

FORMATION	THICKNESS	DEPTH	CHARACTER OF STRATA NOTED BY DRILLER	RESULTS
	30	30	Red clay	
	473	503	Blue shale	
	6	509	Green sand	
Basin shale	5	514	Blue shale	
	6	520	Dry sand	
	350	870	Sandy shale	
	306	1176	Blue shale	
	24	1200	Shells	
	182	1382	Blue shale	
	62	1444	Sand	Water at depth of 1412
	15	1459	Brown shale	
	20	1479	Sand	
	67	1546	White shale	
Benton formation	10	1556	Sand	
	44	1600	Brown shale	
	36	1636	Sand	
	19	1655	Brown shale	
	47	1702	Sand	Gas at depth of 1702

Well No. V-1. Owned by the Fullerton Oil Company. Located in the southwest corner of Section 36, T. 48 N., R. 100 W. Elevation at the mouth of the well 5865 feet above sea level. The well was drilled during the summer and fall of 1914. Log data has not been released for publication, but it is reported unofficially that gas was obtained at a depth of 1570 feet.

Well No. O-1. Owned by the Ohio Oil Company, local headquarters at Thermopolis, Wyoming. Located in the southeast corner of the northwest quarter of Section 2, T. 47 N., R. 100 W. Elevation at the top of the casing, 5945 feet above sea level. The well was drilled during August and September, 1914. The following log of this well was furnished by Mr. M. D. Woolery, by permission

from Mr. John McFadyen, field manager of the Ohio Oil Company:

LOG OF OHIO OIL COMPANY'S WELL NO. O-1

FORMATION	THICKNESS	DEPTH	CHARACTER OF STRATA NOTED BY DRILLER	RESULTS
	480	480	Black shale	.....
Basin shale	25	505	Green sand	Dry
	715	1220	Black shale	.....
	15	1235	Black sand	Dry
	230	1465	Black shale	.....
	10	1475	Sand	Water
	20	1495	Hard sand	Dry
	15	1510	Hard sand	Water
Benton formation	30	1540	Hard sand	Dry
	148	1688	Shale	.....
	14	1702	Sand	Dry
	28	1730	Shale	.....
	5	1735	Sand	Dry
	15	1750	Sand	Gas
	17	1767	Sand	Gas and water
	25	1792	Sand	Big gas

It should be noted that the upper part of the first 480 feet of shale passed through belongs to the Pierre shale, but lack of detail information regarding the kind of beds passed through renders it impossible to separate the Pierre from the Basin shale.

A comparison of the logs of these two wells shows that the first water encountered was reached at a depth of somewhat over 1400 feet, in a sandstone, or sandy beds ranging in thickness from 62 to 75 feet. This thickness compares with 62 feet for the top sandstone member of the Benton, as measured on Wood River. Below these water-bearing sandstones is a considerable amount of shale and shaly sandstone, amounting to somewhat more than 150 feet, before the next hard sand is reached. On Wood River these shales measure 167 feet in thickness. Below this horizon the logs show mostly hard sandstone down to the bottom of the wells. Plate IV shows the relation between logs of the Grass Creek and Buffalo Basin fields and the Wood River section.

The log of the Ohio well shows two water horizons at the top of the Benton, 20 feet apart. If the lower one is taken as the one that corresponds to the water sands of the other two wells, then the thickness of the beds between the water level and the "big gas" sand is 297 feet for the Ohio Company's well, and 320 feet for the Midwest well. This comparison tends to show that the "big gas" horizon is the same in both of the wells, if the water sands are at the same horizon, which cannot be doubted because of the close check with the Wood River section, as already noted above. There seems, therefore, to be little room to doubt that the gas horizons in Little Buffalo Basin are in the central part of the sandstone series shown in the Wood River section, and that they are several hundred feet above the Mowry beds, and over 1000 feet above the Cloverly.

PRODUCTION

The gas wells of Little Buffalo Basin are capable of a large production as is shown by the following estimates supplied by the different companies:

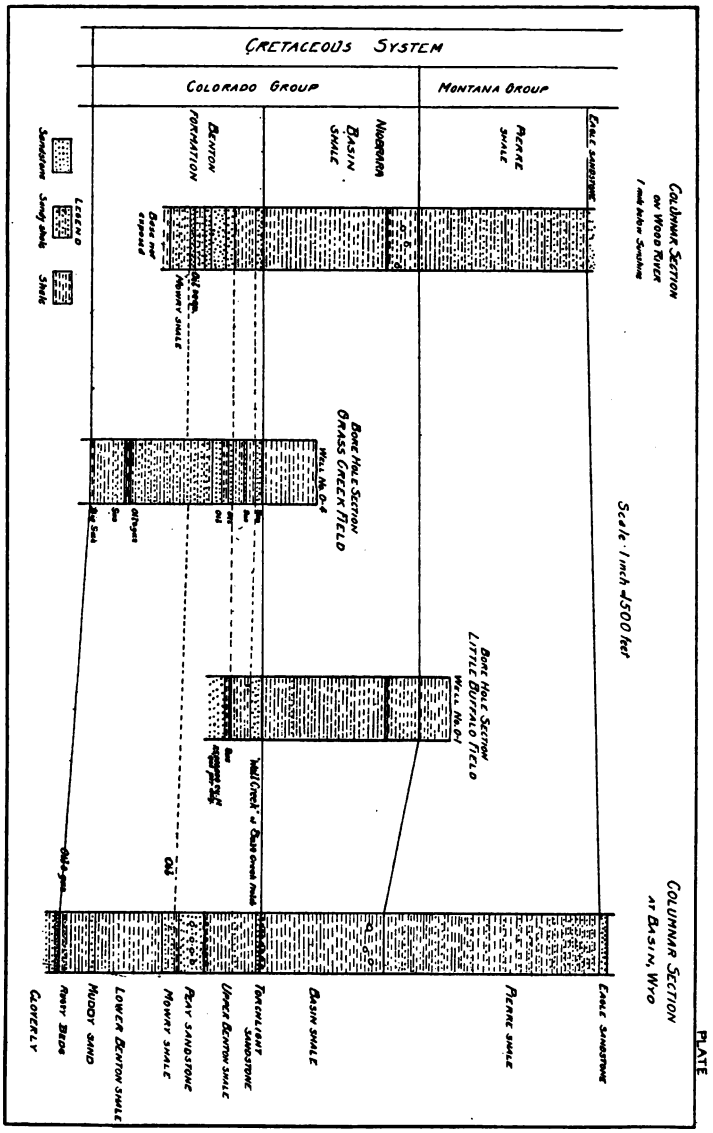
The Ohio well when first brought in is said to have produced between 20 and 40 million cu. feet of gas per day. The pressure at this well has been decreasing until, at the latest report, it is said to have very little, if any pressure. This is possibly due to its unfavorable location in the bottom of the sag between the two domes, but more probably due to cavings.

No estimate of the amount of gas produced by the Midwest well has been received.

Mr. Walker reports that the Fullerton Oil Company's well, Valentine No. 1, will produce in the neighborhood of 23½ million cubic feet of gas per day from the "big gas" sand. Other sands will give an additional 8,000,000 cubic feet, making in all over 30,000,000 cu. ft. per day.

At present all of the wells are capped and are producing several gallons of gasoline per day from the pipe connections to the Braden heads.

PLATE IV.



PLATE

POSSIBILITIES OF DEVELOPMENT

The possibilities of development in the Little Buffalo Basin are apparently very good, as only the upper sands have been penetrated as yet, and the lower sands may be found productive as they are in the Grass Creek field, not far distant, and in most of the other fields in Bighorn Basin. The presence of oil has not been proved, but thus far only four holes have been put down, and there are many promising locations still to be tried. Oil will very likely be found if holes are drilled far enough down on the side of the domes.

GEOLOGIC AND STRUCTURE MAP

EXPLANATION OF STRUCTURE CONTOURS

The geologic structure of each field is represented by the blue structural contours on the geological map. These lines show the position of the upper surface of the top member (Peay sandstone) of the Benton formation with regard to sea level. The contour interval is 100 feet, and the figures placed along the lines show the distance of each contour above sea level. Since the surface contours of topographic maps*, issued by the United States Geological Survey, are also based on sea level, the depth of the sandstone at any particular point is the difference between the two elevations. No surface contours are shown on the geologic map, but the surface elevation is shown at frequent points.

Knowing the position of any other stratum, with reference to the uppermost Benton sandstone, its depth below the surface is readily determined after finding the depth of the contoured sandstone.

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*Topographic maps of Meeteetse (Little Buffalo Basin) and Ilo (Grass Creek) Quadrangles may be obtained from the U. S. G. S., Washington, D. C., at a cost of 10 cents each.

Bulletin No. 11
Part II.

The Grass Creek Oil and Gas Field

Hot Springs County, Wyoming

By
F. F. HINTZE, Jr.

L. W. TRUMBULL, STATE GEOLOGIST

TABLE OF CONTENTS

	PAGE
Acknowledgments	93
Location of Field	93
Geology	93
Topography	93
Drainage	94
Stratigraphy	95
Introduction	95
Table of Formations	97
Description of Formations	98
Lower Cretaceous System	98
Cloverly Formation	98
Upper Cretaceous System	98
Colorado Group	98
Benton Formation	98
Basin shale	98
Montana Group	98
Pierre shale	98
Correlation	99
Structure	100
Grass Creek Dome	100
Little Dome	101
Faulting	102
The Wells	102
Location	102
Oil and Gas Sands	103
Comparative Table of Oil and Gas Sands	104A
Description of Wells	104
Wells of Midwest Oil Company	104
Wells of Fullerton Oil Company	110
Wells of Ohio Oil Company	113
Occurrence of the Oil and Gas	119
Character of Oil and Gas	119
Analysis of Crude Oil from Grass Creek	120
Production	120

The Grass Creek Oil and Gas Field

ACKNOWLEDGMENTS

Thanks are due to the companies operating in the Grass Creek Basin for their hospitality, and for their willingness to furnish information regarding the results of drilling. Special thanks are due to Mr. T. S. Harrison, of Wiley, Wyoming, Mr. W. L. Walker, Basin, Wyoming, and Mr. John McFadyen, Thermopolis, Wyoming, Field Manager of the Ohio Well Co., for logs of the wells of their respective companies. To Mr. M. D. Woolery, Civil Engineer, Thermopolis, Wyoming, thanks are due for the use of his preliminary map of the Grass Creek Oil field.

LOCATION OF FIELD

The Grass Creek oil and gas field is located in Hot Springs County, Wyoming, on the west side of the Bighorn Basin, 35 miles northeast of Thermopolis. It can be reached from points on the Burlington Railroad, by automobile or livery from Thermopolis or Worland; or by stage from Worland to Dickie, and thence by special conveyance. The general location of the field is shown on the accompanying outline map of the state. (See Part I.)

GEOLOGY

Topography

Grass Creek is a depression having a crescent-shaped outline, the curved margins of which are concave toward

the northeast, with the two ends pointing north and east. The east end is pointed, but the northern termination is rounded and blunt. The walls of the basin are steep on the inner sides, becoming precipitous on the northeast side where the sandstone layers are gently inclined. From the top of the basin walls, which rise to a fairly uniform height of about 6100 feet above sea level, the rock layers slope outward toward adjacent valleys outside the basin. Thus the topography of the basin walls is closely related to the geologic structure.

The floor of the basin is somewhat rough and dissected in the northern half, and along the northeast side. South of Grass Creek the surface is more regular and even, sloping gently from the sides toward the center. The most striking feature of the basin floor is a narrow, flat-topped hill, about one mile in length, which occupies a sub-central position. The height of the northwest end of this narrow elevation is 5814 feet above sea level. At the southeast end it is approximately 100 feet lower, giving a slope to the surface of about 100 feet to the mile. This parallels closely the slope of the even portion of the valley floor along Grass Creek, both in amount and direction.

Drainage

The principal stream in the basin is Grass Creek which flows through the southern half of the valley, entering from the west at a point opposite the center of the basin and passing out at its southeastern extremity. A low divide crosses the center of the valley, from the northeast to the southwest, dividing its area into two parts which belong to separate drainage basins. Grass Creek on the south passes southeastward into Meeyero Creek which flows east and joins Bighorn River at Winchester. The drainage of the north half passes out through a narrow gap in the northeastern rim of the basin, and joins Gooseberry Creek which flows by a direct course eastward to the Bighorn River.

The history of the drainage of this region probably

involves many readjustments in the course of the various streams. The larger streams, such as Gooseberry Creek and Grass Creek, seem to flow along channels quite independent of the structure. In this they resemble superimposed streams which had their original directions determined by the slope of strata that have been removed by erosion. These beds were the soft shales and sandstones of the early Tertiary which covered over the folded and peneplained rocks of the Cretaceous and older systems. The streams that accomplished the removal of these superficial strata were flowing along well-established courses by the time they had reached the peneplained surface of the older rocks, and seem to have been able to maintain these courses across hard and soft layers without important changes in direction. Along belts of soft rock subsequent streams, chiefly tributary to the principal streams, were developed, and, among these, adjustments have been many. The drainage area of one has often been decreased by the capture of part of it by some more powerful stream, or one more favorably located on soft and easily eroded beds. Thus, the northern half of Grass Creek Basin is now drained by a small intermittent stream which has worked back from Gooseberry Creek, or one of its tributaries, by headward erosion, until it has robbed Grass Creek of half the drainage area of the basin. That the drainage was formerly to the southeast by way of Grass Creek is shown by the slope in that direction of the flat-topped hill, already mentioned as occurring in the central part of the basin. The surface of this hill, which is over 100 feet higher than the present valley floor along Grass Creek, is a remnant of the basin floor as it was at some time in the past when the center of the basin was all at the level of the top of the hill.

STRATIGRAPHY

Introduction

The rocks exposed in the Grass Creek oil and gas field are all of Cretaceous age and belong chiefly to the Montana

group. The top of the Colorado shale is exposed in the central part of the field, and is surrounded on all sides by the Pierre shale which occupies all of the rest of the valley floor. Overlying the Pierre is the Eagle sandstone, which on account of its superior hardness, has withstood erosion and now forms the walls or rim of the basin. Outside the rim of the basin are the later Montana sediments, known as the Meeteetse formation.

The succession of formations together with their thicknesses and chief characteristics is shown in the following table:

TABLE OF FORMATIONS

SYSTEM	GROUP	FORMATION	THICKNESS IN FEET	CHARACTERISTICS
Eocene		Fort Union	3000	Gray and drab sandy shales, and light brown massive sandstones. Conglomeratic in the lower part.
		UNCONFORMITY Ilo	900 to 850	Buff and yellow sandstones, with minor sandy shale and clay. No coal beds; saurian bones and fresh-water invertebrate fossils.
Upper Cretaceous	Montana	Meeteetse	1000 to 1100	Dark and light gray alternating shales and shaly sandstone, and numerous beds of lignitic coal.
		Eagle	500 to 600	Hard gray and light brown massive sandstones alternating with more thinly bedded shaly sandstone, locally coal-bearing in the lower part. Forms high ridges, due to superior hardness.
		Pierre	1300 to 1400	Light gray and light brown sandy shales and massive layers of sandstone near the top. Softer and darker shales in the lower part, with zones of brown sandy shales. Fossiliferous in upper third. *Scaphites hippocrepis* DeKay, *Baculites ovatus*, etc.
	Colorado	Basin (Niobrara)	1200 to 1300	Soft, black, adobe shale with limestone concretions often highly fossiliferous. Streaks of hard, red, calcareous shale near the top, often very fossiliferous. *Baculites anceps*, *Scaphites ventricosus*, *Inoceramus*, etc., common near the top.
		Benton	1300 to 1400	Heavy buff and brown sandstones at top, separated by sandy shales making up 450 feet; followed below by hard, gray, sandy shales with numerous fish-scales—the Mowry beds. Below the Mowry are black adobe shales and gray sandstones. Black and dark gray shale, with rusty sandstone at the base.*
Lower Cretaceous		Cloverly	100 to 300	Gray, green and maroon shales, and massive gray sandstone.

*The description of the lower part of the Benton here given is taken from the section given by Mr. E. G. Woodruff in his report on the coal fields of the southwest side of the Bighorn Basin, U. S. Geol. Survey Bull. 341, p. 202, 1909.

DESCRIPTION OF FORMATIONS*

Lower Cretaceous System

Cloverly Formation. Deep well borings in the central part of the Grass Creek basin have proved the presence of the Cloverly in this field, buried beneath a cover of over 1700 feet of Colorado shale and sandstone. The identification rests upon the discovery of the brightly colored clays at that depth, which corresponds very closely to the depth at which it was expected to be reached from an estimate based on the thickness of the Colorado shales of this region. There can be no room for doubt, therefore, that the Cloverly is present in this field.

Upper Cretaceous System

COLORADO GROUP

Benton Formation. The Benton formation does not outcrop in the basin or its immediate vicinity. On Wood River, seven miles to the west of Little Buffalo Basin, the upper part is exposed, and on Gooseberry Creek, southeast of Sunshine, the entire formation outcrops.

The estimated thickness of the Benton is 1300 to 1400 feet, as shown in the table of formations, page 97. A deep boring in the central part of the basin (See log of well No. O-4) shows the thickness of the Benton there to be a little over 1300 feet.

Basin Shale. Information relative to the Basin Shale on Page 76, Part I, is applicable to the Grass Creek field.

MONTANA GROUP

Pierre Shale. The thickness of these sandy shales as measured on the east side of the Grass Creek Basin, between the lowest massive layer of the Eagle sandstone and the top of the Basin shale is 1575 feet. This is somewhat less than was found on the east side of the Bighorn Basin, where the Pierre was between 1600 and 1800 feet thick.

* An extended discussion of the geology is given under Little Buffalo Basin, pages 72 to 80.

At Little Buffalo Basin the thickness of the Pierre is 1315 ft.

CORRELATION

Plate IV gives the columnar sections of the Basin and Greybull oil and gas field, and the Wood River section as it was measured at a point about a mile below Sunshine, together with two bore-hole sections constructed from the log data of wells Nos. O-1 and O-4, of the Little Buffalo Basin and the Grass Creek Basin fields, respectively.

The Eagle sandstone member is easily recognized and furnishes a means of correlating the beds at the top of the Pierre shale. The line dividing the Pierre and Basin shales is determined on fossil evidence, the upper layers of the Basin shale carrying an abundant and easily recognizable fauna. The horizontal line separating the Basin shale and the Benton formation is fixed on lithologic grounds, except at Basin where the lower part of the Basin shale is fossiliferous (see page 77). The Mowry shale is the next lower horizon which is recognizable in the Basin and Wood River sections, where it shows its usual characters, being a grayish-blue sandy shale, with abundant fish scales. In the Grass Creek well record sandy beds are reported from this horizon. At Little Buffalo Basin the bottom of the well did not reach the Mowry. The lowest horizon, the Cloverly, is not exposed on Wood River, but was reported in the log of the Grass Creek well, No. O-4, as bright-colored sandy shale carrying water, and is confidently believed to represent the Cloverly of the Basin section.

The productive horizons in the Little Buffalo Basin are in the upper part of the Benton formation, above the Mowry shale. In the Grass Creek field there are productive sands in the Benton both above and below the Mowry shale member, and at Basin and Greybull the Mowry and the Cloverly carry oil and gas. No close correlation of individual sands seems possible between the various fields, but in a general way the uppermost massive sandstones of the Benton seem to correspond, and to be separated from the lower sands by considerable shale.

STRUCTURE

The interesting structural features of the Grass Creek field are two domes of unequal size and unlike form, separated by a shallow syncline. The larger of the two domes is the only one studied in detail, and is the one of most economic importance at the present time. As the Grass Creek Basin has been developed on the crest of this dome, the structure and the hardness of the rocks being the controlling factors in the erosion which produced the basin, this dome may be called the Grass Creek dome and will be described under that name.

The two domes of the Grass Creek field are surrounded on all sides by synclines. At the north the Gooseberry syncline lies between the Grass Creek and the Little Buffalo Basin domes; on the northeast the Cretaceous beds pass under the Tertiary beds of the central part of the Bighorn Basin; and on the southwest a broad syncline separates Grass Creek from the Shoshone Mountain uplift, and from the Cottonwood Creek anticline.

The Grass Creek Dome

The Grass Creek dome is one of extremely asymmetrical form, being in reality more pyramidal in form than dome-shaped. It is elongated in a northwest and southeast direction, and has a curved axis, with the concave side of the curve toward the northeast. The northeast slope of the dome is almost flat, and is more gently inclined than the much shorter and steeper side which faces the southwest. A profile section through the central part of the dome, from northeast to southwest, is shown by section D-D′ on plate preceding page 81 (see Part I).

The axis of the Grass Creek dome crosses the southwest corner of Section 18, T. 46 N., R. 98 W., just northeast of Midwest well M-8, and curves toward the north, passing very close to the east boundary of Section 13, in the east-central part of that section, and thence out of the northeast corner of 13, into the southwest corner of

Section 7, holding a course from here on a little east of north and plunging down with a dip of about 12 to 15 degrees. Southeastward from the top of the dome in the southwest corner of Section 18, the axis is straighter, curving but little to conform to the gentle curvature of the basin in that direction. It enters Section 19 between the Ohio wells, O-3 and O-4, crossing Grass Creek and passing a little north of the center of the section and out a short distance south of the quarter-section corner between Sections 19 and 20, keeping south of, but close to the present stream channel of Grass Creek. It also plunges in this direction, but much less steeply.

The dip of the "rim-rock" along the northeastern side of the basin varies from 13 to 22 degrees, being less variable on this side than elsewhere. On the southwestern side of the basin it reaches a maximum of 57 degrees about a half-mile southeast of the Grass Creek water-gap. Toward the eastern end of the basin the dip lessens, but along the western side it remains steep, while across the northern end of the basin it varies from 25 to 35 degrees. The exact value of the dip at short intervals along the Eagle sandstone contact surrounding the basin is shown by dip and strike signs on the structure map, following Page 80.

The Little Dome

No survey was made of the little dome which lies northwest of the Grass Creek dome. But a preliminary inspection of it from the high ground in its central portion, shows that it is nearly circular in outline and more symmetrical in form than the Grass Creek dome. It is, however, somewhat steeper on the west and southwest than it is on the side nearer to the larger structure of the Grass Creek Dome, and in this detail it follows the rule that the steeper limb faces the nearest mountain range and that the axis is parallel to that range. Its central portion is covered with the Pierre shale, and as no section was made across it, and there are no easily recognizable horizons within the Pierre, it is

impossible to say just what the depth would be to the oil and gas sands. From an estimate hurriedly made it seems that at least 1000 feet of Pierre must cover the Colorado shales and sand in the central part of this dome and that to reach the oil and gas sands of the upper Benton a hole close to 2500 feet deep would be required.

Faulting

Faulting was observed at the northern and southern ends of the basin, along the Pierre-Eagle contact. The direction of movement is not determinable, but the effect is to offset the inclined beds somewhat. The displacement of the fault at the northern end of the basin is several hundred feet. The brecciated zone can be distinctly seen, and the effect on the topography is noticeable, in that the southwestern block, which is offset toward the south, juts out into the basin producing an offset in the massive escarpment. The strike of the fault is 20 degrees west of north.

The fault at the southeastern end of the basin is of less displacement. Its strike is nearly due east, and the effect of the movement is the off-setting of the beds on the north side toward the east, with a displacement of approximately 75 feet.

Both of these faults appear to be lost in the soft shales of the basin floor, but can be traced along the sandstone beds for considerable distance. They seem not to have any effect on the structure of the dome in the vicinity of the oil wells.

THE WELLS

Location

The wells of the Grass Creek Basin are all located in the central part of the basin near the top of the dome. Most of the wells thus far drilled are on the northeastern side of the dome, only four wells having been located west or southwest of the axis. They are all started in Colorado

shale, except one, and it is too far from the center of the structure to be productive.

In all 23 wells have been drilled in the basin, out of which 14 are oil wells, 7 water wells, and 2 are unfinished. Wells located outside of the area of Colorado shale will probably be water wells, or dry holes, as all of the oil wells so far brought in are within the 4700 foot structure contour line.

Oil and Gas Sands

The highest productive sandstone of the Grass Creek field is of Benton age, being the uppermost part of that formation. There is a series of sandstones and shales near the top of the Benton (see section under Benton page 75, and Plate II-B) in which apparently seven different sands carry oil or gas in the various wells. The upper one usually has some water in it, and is known to the drillers as the "water sand", but in the Fullerton Oil Company's well, V-2, gas has been reported to occur along with the water. In the table given below this sand is given as sand No. 1, and the depth to the bottom of the other sands is reckoned from the top of the "water sand", or sand No. 1.

In arranging the following comparative table of oil and gas sands the writer has endeavored to correlate the sands as nearly as the log data would permit, and in some cases where the depth from the "water sand" varies greatly from the rest of the values in the same horizontal line, the sand may be a "stray" or an additional sand which has not been separately reported in the logs of the other wells. In most of the wells sand No. 6 occurs at a fairly uniform depth of 325 to 375 feet below the top of the "water sand", and in the case of sand No. 7 there is very striking correspondence in the depth figures. These numbers represent very closely the average thickness of the Benton sandstone series in this field, if the dip of the beds is neglected. The exact thickness is, of course, somewhat less. If a uniform dip of 10 degrees be assumed for the beds, and the average depth be taken as 460 feet in the wells, then the thickness

of the series between the "water sand" and the bottom of No. 7 is 453 feet. It is fair, therefore, to consider the thickness of the series as about 450 feet.

The sands below No. 7 belong to the lower part of the Benton formation, and the lowest water sand, No. 12, possibly is the Cloverly. According to the drillers of well No. O-4, the last beds penetrated were highly colored and answer the description of the varigated Cloverly. In well M-6, the depth is greater; no statement has been made as to the character of the last sand, but there seems to be little reason to doubt that it is at least as low as the top of the Cloverly.

Description of Wells

WELLS OF MIDWEST OIL COMPANY

Well No. M-1. Owned by Midwest Oil Co., Casper, Wyoming. Located in the southeast corner of the northeast quarter of Section 12, T. 46 N., R. 99 W. This well was drilled during October, 1914. The log of this well was not furnished, but it is known that water was encountered in the oil and gas sands. The elevation at the mouth of the well is 5655 feet above sea level. According to its location on the side of the dome, it is probable that the conditions encountered in drilling are very similar to those reported from Well No. M-4.

Well No. M-2. Owned by the Midwest Oil Co., Casper, Wyo. Located on the northwest quarter of Section 7, T. 46 N., R. 98 W. This well was drilled during September and October, 1914. The log of this well was not obtained, but it is reported to be a water well. The elevation at the mouth of the well is 5655 feet above sea level. From a consideration of the location of this well at the end of the dome, at about the same position, structurally, but topographically about 40 feet higher than Well No. M-4, it may be expected that the logs of the two wells will not differ greatly. The sands in M-2 probably occur about 50 feet higher than those of M-4.

Thickness of Oil and Gas Sands, and Depth from Top of "Water Sand"		
Oil or (and) Gas Sands	No. 1	Thickness Depth
	No. 2	Thickness epth
	No. 3	Thickness Depth
	No. 4	Thickness Depth
	No. 5	Thickness Depth
	No. 6	Thickness Depth
	No. 7	Thickness Depth
	No. 8	Thickness Depth
	No. 9	Thickness Depth
	No. 10	Thickness Depth
	No. 11	Thickness Depth
	No. 12	Thickness Depth

* Small letter

Well No. M-3. Owned by Midwest Oil Company, Casper, Wyo. Located in the southeast quarter of the southwest quarter of Section 7, T. 46 N., R. 98 W. The elevation at the mouth of the well is 5630 feet above sea level. The following is the log of this well, as furnished by Mr. T. S. Harrison, Field Manager of the Midwest Oil Company in the Grass Creek field:

LOG OF MIDWEST WELL NO. M-3

PROBABLE FORMATION	THICKNESS	DEPTH	CHARACTER OF STRATA NOTED BY DRILLER	RESULTS
Basin shale	700	700	Shale	
Benton	18	718	Sand	Water
	5	723	Shale	
	12	735	Sand	Water
	95	830	Shale	
	20	850	Sand	
	44	894	Shale	
	12	906	Shale with shells	
	16	922	Sand	Oil
	34	956	Shale	
	18	974	Sand	Oil
	42	1016	Shale	
	19	1035	Sand	Oil and some water
	99	1134	Shale	
	25	1159	Sand	Oil

From the foregoing log it appears that the productive sands belong to the upper part of the Benton formation. The well was started in Basin shale, and the first 700 feet of shale passed through probably all belongs to that formation, while the sandy beds in which the oil and water were found belong at the top of the Benton.

Well No. M-4. Owned by the Midwest Oil Company, Casper, Wyo. Located in the southeast corner of the southwest quarter of Section 7, T. 46 N., R. 98 W. The elevation at the mouth of the well is 5615 feet above sea level. This well was drilled during August and September, 1914. The following is the log of this well, furnished by Mr. T. S. Harrison, Wiley, Wyo.

LOG OF MIDWEST WELL NO. M-4

PROBABLE FORMATION	THICK-NESS	DEPTH	CHARACTER OF STRATA NOTED BY DRILLER	RESULTS
Basin shale	30	30	Sub-soil	
	170	200	Shells	
	635	835	Blue shale	
Benton	20	855	Sand	Water
	45	900	Blue shale and shells	
	25	925	Bentonite and shale	
	30	955	Blue shale and shells	
	15	970	Sand	
	25	995	Bentonite and shale	
	17	1012	Blue shale	
	18	1030	Broken lime	
	11	1041	Sand	Odor of oil
	34	1075	Talc	Bailer of water
	12	1087	Blue shale	
	48	1135	Talc (lime and bentonite)	
	25	1160	Sand	Water, odor of oil
	5	1165	Sand	

Well No. M-5. Owned by the Midwest Oil Company, Casper, Wyo. Located in the southwest corner of the southeast quarter of Section 7, T. 46 N., R. 98 W. The elevation at the mouth of the well is 5600 feet above sea level. This well was drilled during August, 1914. The following is the log of this well, as furnished by Mr. T. S. Harrison, Wiley, Wyoming.

LOG OF MIDWEST WELL NO. M-5

PROBABLE FORMATION	THICK-NESS	DEPTH	CHARACTER OF STRATA NOTED BY DRILLER	RESULTS
Basin shale	215	215	Blue shale	
	110	325	Sandy shale	
	45	370	Blue shale	
	20	390	Sandy shale	
	545	935	Blue shale	
Benton	30	965	Sand	Water
	70	1035	Sandy shale	
	20	1055	Sand	Water
	25	1080	Sandy shale	
	138	1218	Shell	Slight showing of oil
	8	1226	Shale	
	30	1256	Sand	Water and showing of oil

This well is located on the same quarter-section as the Fullerton Oil Company's well No. V-1, and only a short distance northwest of that well. It was drilled in competition with the Fullerton well in an effort to make the first discovery of gas, or oil, on the quarter-section, and thus obtain first claim upon the land. The results tend to prove that the southeast quarter of Section 7 is not to be classed as oil or gas land.

Well No. M-6. Owned by the Midwest Oil Company, Casper, Wyo. Located in the southeast corner of the southeast quarter of Section 12, T. 46 N., R. 99 W. Elevation at the mouth of the well is 5670 feet above sea level. Oil was obtained in this well in the sandstones of the upper Benton. The drilling was continued through to the Cloverly, in which water was encountered. The following is the log of the well, as furnished by Mr. T. S. Harrison, Wiley, Wyoming.

LOG OF MIDWEST WELL NO. M-6

PROBABLE FORMATION	THICKNESS	DEPTH	CHARACTER OF STRATA NOTED BY DRILLER	RESULTS
Basin shale	601	601	Shale	
Benton	18	619	Sand	Water
	189	808	Shale	
	18	826	Sand	Oil
	87	913	Shale	
	22	935	Sand	Oil
	95	1030	Shale	
	30	1060	Sand	Oil
	190	1250	Shale and shells	
	150	1400	Lime	
	430	1830	Shale	
	230	2060	Shale	
Cloverly		2060	Sand	Water

According to this log the sandstone series near the top of the Benton is 440 feet thick, and the shales between these sands and the top of the Cloverly are 1000 feet in thickness. This includes the Mowry beds which are prob-

ably represented in the 190 feet of "shale and shells" which underlie the lowest oil sand.

Well No. M-7. Owned by the Midwest Oil Company, Casper, Wyo. Located in the southeast corner of the northeast quarter of Section 13, T. 46 N., R. 99 W. Elevation at the mouth of the well is 5695 feet above sea level. This well was started July 20, 1914, and finished August 8, 1914. It is the first gas-producing well of the Grass Creek anticline. The gas was encountered near the top of the upper Benton sandstones. The oil was obtained at a greater depth, also occurring in the upper Benton sands, but near their base. The following is the log of this well as furnished by Mr. T. S. Harrison, Wiley, Wyoming.

LOG OF MIDWEST WELL NO. M-7

PROBABLE FORMATION	THICKNESS	DEPTH	CHARACTER OF STRATA NOTED BY DRILLER	RESULTS
Basin shale	365	365	Muddy shale	
	25	390	Sand	Water
	50	440	Sandy shale	
	8	448	Sand	Little gas
	5	453	Shale	
	17	470	Sand	
	25	495	Sandy shale	
	45	540	Sand	Gas
	35	575	Shale	
Benton	30	605	Sand	Greater gas
	19	624	Sandy shale	
	1	625	Shale marl	
	15	640	Broken shale	
	15	655	Sand	
	5	660	Shale	
	32	692	Sandy shale	
	15	707	Sand	Oil

From a consideration of the logs of the deeper wells of the district it appears that the oil sand in this well is not the lowest productive sand of the upper Benton series. The thickness of the Benton penetrated in this well is 347 feet, whereas the thickness of the sandstone series is about

440 feet, so that there is very likely a lower oil sand that can be reached by deeper drilling.

Well No. M-8. Owned by the Midwest Oil Company, Casper, Wyo. Located on the southeast quarter of Section 13, T. 46 N., R. 99 W. Elevation at the mouth of the well is 5690 feet above sea level. This well was drilled during September, 1914. The following is the log of this well, as furnished by Mr. T. S. Harrison, Wiley, Wyo.

LOG OF MIDWEST WELL NO. M-8

PROBABLE FORMATION	THICKNESS	DEPTH	CHARACTER OF STRATA NOTED BY DRILLER	RESULTS
Basin shale	385	385	Shale	
Benton	20	405	Sand	Water
	171	576	Shale	
	24	600	Sand	Gas
	92	692	Shale	
	20	712	Sand	Oil
	66	778	Shale	
	47	825	Sand	Oil

The gas sand reported at a depth of 600 feet corresponds to the "greater gas" sand in well No. M-7; and the upper oil sand of this well is the same as the oil sand of that well. The lower oil sand of this well was not reached in M-7.

Well No. M-9. Midwest Oil Company, Casper, Wyoming, owners. Located on the north half of the northeast quarter of Section 19, T. 46 N., R. 98 W. Elevation at the mouth of the well is 5645 feet above sea level. This well was commenced July 27, 1914, and completed August 21, 1914. Oil was encountered at several horizons in the upper Benton sandstone series. The oil is said to be of light gravity and of a light-green color. The following is the log of this well, as furnished by Mr. T. S. Harrison, Wiley, Wyoming.

LOG OF MIDWEST WELL NO. M-9

PROBABLE FORMATION	THICKNESS	DEPTH	CHARACTER OF STRATA NOTED BY DRILLER	RESULTS
Basin shale	449	449	Black shale	
	22	471	Sand	Water
	52	523	Shale	
	8	531	Sand	Water
	3	534	Shells	
	10	544	Bentonite	
	2	546	Shells	
	4	550	———	Showing of oil
	30	580	Sand	Oil
	58	638	Hard shale	
Benton	10	648	Hard sand	
	2	650	Shell	
	12	662	Sand	Oil
	20	682	Shale	
	11	693	Sand	
	73	766	Blue shale	
	30	796	Sand	Oil
	2	798	Blue shale	

The total thickness of Benton shale and sandstone penetrated in this well is the same as that in No. M-7, 347 feet, which is less than the total thickness of the sandstone series by nearly 100 feet. In some of the wells oil is found at the base, and there is probably a lower oil sand in this well that can be reached in drilling another 100 feet.

WELLS OF THE FULLERTON OIL COMPANY

Well No. V-1. Owned by the Fullerton Oil Company, Los Angeles, California. Located in the southwest corner of the southeast quarter of Section 7, T. 46 N., R. 98 W. Elevation at the mouth of the well 5600 feet above sea level. Log withheld, but it is reported that all sands were encountered 15 feet higher than in Midwest well No. M-5 (see log of M-5).

Well No. V-2. Owned by the Fullerton Oil Company. Located on the southwest quarter Section 18, T. 46 N., R. 98 W. Elevation at the mouth of the well 5690 feet above sea level. Well drilled during May and June, 1914.

The following is a log unofficially submitted, but said to be accurate.

LOG OF FULLERTON WELL NO. V-2

PROBABLE FORMATION	THICKNESS	DEPTH	CHARACTER OF STRATA NOTED BY DRILLER	RESULTS
	615	615	Soft black shale	
Basin	4	619	Hard sandstone	
shale	71	690	Soft black shale	
	5	695	Gray sandstone	
	5	700	Sandstone	Gas and water
	10	710	Gray sandstone	Water
	13	723	Sandy dark shale	
	55	778	Hard black shale	
	7	785	White sandstone	
	5	790	Bentonite	
Benton	10	800	Gray sandstone	
	90	890	Sand and dark shale	
	20	910	Sand	Oil and gas
	210	1120	Blue shale	
	30	1150	Sand	Oil and gas
	90	1240	Black shale	

This well is known to have produced oil and gas at a depth of 900 to 1100 feet which corresponds to the horizon of the lower part of the Benton sandstone series. No official information has been obtained regarding the nature of the oil or gas but they are thought to be similar in character to that of the Ohio well No. O-2. The lowest oil sand of the upper Benton appears to have been reached in this well, at a depth of 455 feet from the top of the Benton.

Well No. V-3. Owned by the Fullerton Oil Company. Located in the southwest corner of the northeast quarter of Section 18, T. 46 N., R. 98 W. Elevation at the mouth of the well 5670 feet above sea level. This well was not completed owing to litigation, but was drilled to a depth of about 800 feet, during the month of June. The following is a partial log of this well unofficially reported.

PARTIAL LOG OF FULLERTON WELL NO. V-3

PROBABLE FORMATION	THICKNESS	DEPTH	CHARACTER OF STRATA NOTED BY DRILLER	RESULTS
Basin shale	755	755	Black shale	
	?	800	Oil sand not reached	

Well No. V-4. Owned by the Fullerton Oil Company. Located in the southwest corner of the southwest quarter of Section 17, T. 46 N., R. 98 W. Elevation at the mouth of the well 5675 feet above sea level. The official log of this well has not been obtained, but it is reported that water was obtained, and possibly a small amount of gas. The following is a log of this well as unofficially reported:

LOG OF FULLERTON WELL NO. V-4

PROBABLE FORMATION	THICKNESS	DEPTH	CHARACTER OF STRATA NOTED BY DRILLER	RESULTS
Basin shale	290	290	Shale	
	25	315	Stray sand	
	707	1022	Shale	
Benton	15	1037	Sand	Water
	33	1070	Shale	
	10	1080	Sand	Dry
	40	1120	Shale	
	30	1150	Sand	Water
	90	1240	Shale	
	18	1258	Sand	Water
	38	1296	Shale	
	24	1320	Sand	Water (rose 400 ft.)
	35	1355	Shale	
	30	1385	Sand	Water, (rose within 400 feet of top)

The thickness of the Benton sandstones passed through in this well is less than the total thickness of the series by nearly 100 feet. The water sand at the bottom of the hole corresponds to the oil sand above the lowest oil sand of the upper Benton series.

Well No. V-5. Owned by the Fullerton Oil Company. Located on the northwest quarter of the northwest quarter of Section 20, T. 46 N., R. 98 W. Elevation at the mouth of the well, 5650 feet above sea level. No official information has been obtained regarding this well but it is reported that oil in small quantity was obtained, and it is believed that the well is located very near the outer margin of the oil-bearing zone. The following is a partial log:

PARTIAL LOG OF FULLERTON WELL NO. V-5

PROBABLE FORMATION	THICK-NESS	DEPTH	CHARACTER OF STRATA NOTED BY DRILLER	RESULTS
Basin shale	890	890	Shale	.....
Benton	? ?	890 1053	Top of sand ..... Top of sand	Water Oil

Well No. V-6. Owned by the Fullerton Oil Company. Located in the northwest quarter of the southwest quarter of Section 20, T. 46 N., R. 98 W. Elevation at the mouth of the well, 5590 feet above sea level. No information has been released regarding this well, but it is known to be an oil well and is located well within the oil-producing zone of the upper Benton sandstones. The well was drilled during December, 1914, and January, 1915.

WELLS OF OHIO OIL COMPANY

Well No. O-1. Owned by the Ohio Oil Company. Local office Thermopolis, Wyoming. Located on the northwest quarter of Section 18, T. 46 N., R. 98 W. Elevation at the mouth of the well 5665 feet above sea level. In this well oil was obtained at three horizons within the upper Benton sandstone series. No statement as to quantity of oil found in the different sands has been submitted. The quality of the oil is said to be the same as that found in Ohio well No. O-2, which has a gravity of 45 Baume, and the quantity may be about the same as that of the latter well which made 260 barrels during the first 24 hours that it was pumped. The following is the official log:

LOG OF OHIO WELL NO. O-1

PROBABLE FORMATION	THICK-NESS	DEPTH	CHARACTER OF STRATA NOTED BY DRILLER	RESULTS
Basin shale	540	540	Black shale	
	25	565	Sandstone	Water
	50	615	Blue shale with sandy shells	
	3	618	Hard sandstone	
	22	640	Blue shale	
	30	670	Bentonite	
	10	680	Blue shale	
Benton	30	710	Shale and bentonite	
	25	735	Blue shale	
	6	741	Broken sand	
	2	743	Hard sandstone	
	12	755	Sandstone	Oil
	45	8000	Bentonite with shells	
	5	805	Sandstone	
	21	826	Bentonite	
	10	836	Blue shale	
	5	841	Bentonite	
	7	848	Blue shale	
	17	865	Sandstone	Oil
	96	961	Dark shale	
	33	996	Sand	Oil
	51	1047	Shale	

The lowest oil horizon of the Benton sands seems to have been reached in this well at a depth of 996 feet. Between the bottom of this sand and the top of the Benton is a thickness of 446 feet of strata, which corresponds closely to the total thickness of the series as reported in the log of other wells.

Well No. O-2. Owned by the Ohio Oil Company. Located on the northeast corner of the southwest quarter of Section 18, T. 46 N., R. 98 W. Elevation at the mouth of the well is 5690 feet above sea level. This well was drilled during August, 1914. The following is the log of this well as furnished by Mr. M. D. Woolery, Thermopolis, Wyoming.

LOG OF OHIO WELL NO. O-2

PROBABLE FORMATION	THICKNESS	DEPTH	CHARACTER OF STRATA NOTED BY DRILLER	RESULTS
Basin shale	630	630	Shale	
	20	650	Sand	Water
	162	812	Shale	
	20	832	Sand	Oil and gas
	38	870	Shale	
	14	884	Sand	Oil
	28	902	Shale	
Benton	11	913	Sand	
	11	924	Shale	
	3	927	Sand	Oil
	22	949	Sand	Oil
	5	954	Shale	
	11	965	Shale	

The upper 737.5 feet of this well was cased off with 10-inch pipe to shut out the water from the top sand. A pump was then installed which during the first 24 hours raised 260 barrels of oil, and developed sufficient gas to run the pumping engine. The analysis and description of this oil is given on page 120.

Well No. O-3. Owners, Ohio Oil Company. Located on Lot 1, Section 19, T. 46 N., R. 98 W. Elevation at the mouth of the well is 5675 feet above sea level. In this well oil and gas were obtained at comparatively shallow depths. The well was drilled during September, 1914. The following is the log of this well as furnished by Mr. M. D. Woolery.

LOG OF OHIO WELL NO. O-3

PROBABLE FORMATION	THICKNESS	DEPTH	CHARACTER OF STRATA NOTED BY DRILLER	RESULTS
Basin shale	395	395	Shale	
	26	421	Sand	Little water
	59	480	Shale	
	40	520	Sand	Gas
	70	590	———	
	35	625	Sand	Gas
Benton	20	645	———	
	15	660	Sand	Oil
	30	690	———	
	25	715	Sand	Oil
	35	750	Broken sand	
	19	769	———	

The lowest oil horizon in this well is more than 100 feet

above the base of the sandstone series of the upper part of the Benton. This is judged from the thickness of the sands and shales that occur between the top sand and this oil sand, which is 320 feet.

The amount and quality of the oil are not reported, but are presumably similar to those of other wells in the district.

Well No. O-4. Owners, Ohio Oil Company. Located on the northeast quarter of the northwest quarter of Section 19, T. 46 N., R. 98 W. Elevation at the mouth of the well is 5665 feet above sea level. This well was drilled during August and September, 1914. Oil and gas were obtained in the upper Benton sandstones at a shallow depth and considerable gas was obtained at a depth of 1700 feet, at the approximate horizon of the top of the Cloverly. The following is the log of this well, as furnished by Mr. M. D. Woolery, Thermopolis, Wyo.

LOG OF OHIO WELL NO. O-4

PROBABLE FORMATION	THICKNESS	DEPTH	CHARACTER OF STRATA NOTED BY DRILLER	RESULTS
Basin shale	400	400	Shale	
	23	423	Shale	Little water
	37	460	Sand	Gas
	70	530	———	
	20	550	Sand	Gas
	90	640	———	
	41	681	Sand	Oil
	47	728	———	
	76	804	Sand	Oil
	622	1426	———	
	15	1441	Sand	Gas and small am't oil
	2	1443	———	
Benton	20	1463	Sand	Gas
	222	1685	———	
	3	1688	Sand	Gas
	7	1695	Sand	Dry
	5	1700	———	
	15	1715	Sand	Big gas
	24	1739	Sand	Water
Cloverly?	1	1740	———	

The first gas was cased off with 12½-inch pipe; the oil above 804 ft. was cased off with 10-inch casing; and the oil and gas above 1430 feet was cased off with 8¼-inch casing. It is believed that the "big gas" will make about

PLATE V-A.

Profile View of Eagle Sandstone escarpment surrounding Grass Creek Basin. Lower scarp only locally developed, within the Pierre Shale. Looking southeast, along the northeast rim of the basin.

PLATE V-B.

Fourteen-horse team moving a portable drilling rig. Grass Creek Field.

6,000,000 cu. feet per day, according to an official report.

The following is a log of this well furnished to the State Geologist by Messrs. Drayton & Good, contractors.

RECORD OF WELL NO. 1

ON THE STATE LAND COMMISSIONER'S FARM, BEING IN THE NE¼ OF THE NW¼ OF SECTION 19, T. 46 N., R. 98 W., HOT SPRINGS COUNTY, GRASS CREEK FIELD

PROBABLE FORMATION	THICKNESS	DEPTH	CHARACTER OF STRATA NOTED BY DRILLER	RESULTS
Basin shale	270	270	Surface soil, gravel and mud	
	35	305	Blue shale	
	95	400	Brown shale	
	23	423	Light shale	Little water
	37	460	Gas sand	Gas
	3	463	Brown shale	
	7	470	Blue shale	
	45	515	Sandy shale	
	15	530	Light shale	
	20	550	Gas sand	Gas
	40	590	Light shale	
	15	605	Sand	
	35	640	Sandy shale	
	41	681	Oil sand	Oil
	21	702	Blue shale	
	18	720	Talc	
	8	728	Shale	
	76	804	Sand, 2nd oil sand	Oil
	11	815	Sandy black shale	
	10	825	Black sandy shale	
Benton	5	830	Hard shell	
	15	845	Black shale	
	15	860	Black sandy shale	
	8	868	Hard shell	
	17	885	Black shale	
	15	895	Hard shell	
	5	900	Shell	
	30	930	Very hard shell	
	15	945	Brown shale	
	3	948	Hard shell	
	32	980	Brown shale	
	8	988	Hard shell	
	438	1426	Brown shale	
	15	1441	Sand	Little gas and oil
	2	1443	Dark shale	
	20	1463	Sand	Gas
	222	1685	Dark shale	
	3	1688	Sand	Gas
	7	1695	Sand	Dry
	5	1700	Shale	
	15	1715	Sand	Big gas
	24	1739	Shale	
Cloverly?	1	1740	Sand	Water

Well No. O-5. Owned by the Ohio Oil Company, Thermopolis, Wyo. Located on Lot 2, T. 46 N., R. 98 W. This well was drilled during October, 1914. The following is the log of this well, furnished by Mr. M. D. Woolery, Thermopolis, Wyoming.

LOG OF OHIO WELL NO. O-5

PROBABLE FORMATION	THICKNESS	DEPTH	CHARACTER OF STRATA NOTED BY DRILLER	RESULTS
Basin shale	451	451	Shale	
	34	485	Broken sand	Dry
	10	495	Shale	
	20	515	Sand	Very little water
	155	670	Shale	
	12	682	Sand	Oil and little gas
	34	716	Shale	
	20	736	Sand	Oil
	39	775	Shale	
	25	800	Sand	Oil
	58	858	Shale	
Benton	14	872	Sand	Oil
	19	891	Shale	
	39	930	Sand	Oil
	2	932	Shale	
	6	938	Sand	Oil (?)
	48	986	Shale	

In this well six different oil sands are reported, as indicated above. The thickness of beds between the water sand and the lowest oil sand is 443 feet, which indicates that the lowest oil-producing sand is at the base of the upper Benton sandstone series.

Well No. O-6. Owned by the Ohio Oil Company. Located in the northwest quarter of the southwest quarter of Section 19, T. 46 N. R. 98 W. The elevation at the mouth of the well is 5680 feet above sea level. The results of the drilling in this well have not been obtained but it seems to be located considerably outside the oil and gas zones of the upper Benton sands.

Well No. O-7. Owned by the Ohio Oil Company. Located in the southwest quarter of the northwest quarter of Section 20. T. 46 N., R. 98 W. The elevation at the

mouth of the well is 5575 feet above sea level. The log of this well has not been submitted, but it is reported that oil was obtained at the same horizon as in the Fullerton well No. V-5, located a short distance to the north.

Well No. O-8. This well was never drilled, the location having been regarded as unfavorable. Structurally it is located similarly to wells No. O-7 and V-5.

OCCURRENCE OF THE OIL AND GAS

The presence of oil and gas in the wells near the top of the dome shows that the occurrence of the oil and gas is in accordance with the well-known anticlinal theory. There is a small area at the top of the dome which yields gas from the upper Benton sands, and surrounding this is a zone that furnishes oil, while still farther out, surrounding the oil zone, the sands are found to be filled with water. The different products are thus seen to be separated according to their specific gravity, with the gas at the top of the dome, and the oil next below, with the water at the base. The planes separating the different zones seem to be nearly horizontal, from the fact that the structure contours as shown on the map following Page 80, define the various zones quite closely. Thus, contour 4700 separates the water wells from the oil wells, and contour 5100, the oil wells from the gas wells.

CHARACTER OF THE OIL AND GAS

The oils obtained from the different wells of the Grass Creek field seem to be very similar in character. They are uniformly greenish in color and have a strong odor of gasoline. A sample taken from well No. O-2 of the Ohio Oil Company, had a gravity of 45° Baume, and upon analysis yielded the following results:

ANALYSIS OF CRUDE OIL FROM OHIO OIL COMPANY'S WELL NO. O-2*

PER CENT.	TEMPERATURE	GRAVITY
10	102 to 186	78.5
20	186 to 234	65.4
30	234 to 280	57.3
40	280 to 346	51.6
50	346 to 320	45.6
60	420 to 500	40.7
15.6	212	——
41.8	350	——
44.2	365	——
61.4		

No analysis of the gas has yet been made, but it may be said that it has a strong odor of gasoline, and burns with a long luminous flame. It seems to be similar to the gas obtained in the Little Buffalo Basin, where gasoline is naturally condensing from the gas in the pipe lines.

PRODUCTION

The capacity of the wells of this field has not been determined except in the case of Ohio well No. O-2, which was pumped for two consecutive days and yielded 260 barrels the first day, and 160 barrels the second 24 hours. This test was, however, too short to determine the average production that may be expected from the wells close by or for the field as a whole. Upon continued pumping for several weeks it is likely that the daily yield will be diminished, and may be less than one hundred barrels per day. An actual test alone can determine the exact amount.† From the uniformity of the oil flow of the different wells it seems reasonable to assume that the sands are saturated everywhere within the oil-bearing zone, and that the net production of the field will be large.

The capacity of the gas wells is small, except the Ohio well No. O-4, which is estimated to yield in the neighborhood of 6,000,000 cubic feet per day.

*Fractional distillation by Standard Oil Co., Casper, Wyoming.

†A six weeks test of two wells gave a uniform combined production of 500 barrels every thirty-six hours.

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